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RESEARCH MEMORANDUM

for the

U. S. Air Force

WIND-TUNNEL FLUTTER TESTS AT MACH NUMBERS UP TO 3.0 OF BOEING WING MODELS FOR WEAPONS SYSTEM 110A

COORD. NO. AF-AM-108

By G. M. Levey, W. J. Tuovila, and A. G. Rainey

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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WIND-TUNNEL FLUTTER TESTS AT MACH NUMBERS UP TO 3.0 OF BOEING WING MODELS FOR WEAPONS SYSTEM 110A

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SUMMARY

Flutter tests have been conducted on two low-aspect-ratio wing plan forms under consideration by the Boeing Airplane Company for the 110A weapons system. These configurations had three heavy nacelles near the trailing edge, and flutter tests were made both with and without the nacelles. Up to a Mach number of 3.0 the dynamic pressure required for flutter of a wing with nacelles was generally higher than that of a wing without nacelles.

INTRODUCTION

The aerodynamic advantages of thin low-aspect-ratio lifting surfaces for supersonic flight have led to an increased interest in the characteristics of such surfaces. A complete description of the aeroelastic characteristics of surfaces of this type is particularly difficult because of the complexities of both structural and aerodynamic analysis of the behavior of this type of wing. Consequently, when the Boeing Airplane Company decided on a thin, low-aspect-ratio lifting surface for their proposal in the Air Force 110A weapons system competition, it was considered desirable to make a preliminary experimental study of the flutter characteristics of two plan forms which were within the range of configurations being considered. It was believed that the flutter problem for the proposed configuration might be particularly acute because of the rearward location of the engine nacelles. Consequently, a series of models have been tested in the Langley 9- by 18-inch supersonic flutter

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tunnel and in the Langley 2-foot transonic flutter tunnel in the Mach number range from about 0.6 to 3.0.

SYMBOLS

a speed of sound, fps

A twice exposed-panel aspect ratio

b semichord at 0.75 span, ft

f_{h_1} first bending frequency, cps

f_{h_2} second bending frequency, cps

f_α first torsion frequency, cps

f_f flutter frequency, cps

m mass of wing, slugs

M Mach number

ρ air density, slugs/cu ft

$\omega_\alpha = 2\pi f_\alpha$

μ mass ratio parameter (see page 4)

APPARATUS AND TESTS

Description of Wind Tunnels

The tests were conducted in the Langley 9- by 18-inch supersonic flutter tunnel in the Mach number range from about 0.6 to 3.0, with some supplemental tests in the Langley 2-foot transonic flutter tunnel in the Mach number range from 0.6 to 1.12.

The Langley 9- by 18-inch supersonic flutter tunnel is a conventional fixed-nozzle blowdown type of wind tunnel exhausting into a vacuum sphere. This tunnel is equipped with interchangeable nozzle blocks which give fixed Mach numbers of 1.3, 1.64, 2.0, and 3.0. In addition, a set of slotted nozzle blocks are used for tests in the range from about M = 0.6 to 1.3.

The Langley 2-foot transonic flutter tunnel is a conventional slotted-throat single-return wind tunnel equipped to use either air or Freon-12 as a test medium. This tunnel is of the continuous-operation type; that is, it is powered by a motor-driven fan. Both the test-section Mach number and the density are continuously controllable.

Description of Models

~~The two configurations tested simulated two possible wing plan forms being considered by the Boeing Airplane Company for the WS110A competition.~~ delete The two plan forms (shown in fig. 1) were identical except for aspect ratio. Both wing designs had a 2.5-percent-thick double-wedge airfoil section with the maximum thickness at the 70-percent-chord station and were unswept at the 75-percent-chord line. The taper ratio was 0.164. The shorter of the two designs, which is referred to herein as the normal-plan-form wing, had an aspect ratio of 1.27, and the longer design, referred to as the extended-plan-form wing, had an aspect ratio of 1.61. The semispan models were tested as cantilevers mounted on a half-body as indicated in figure 2. The aspect ratio and taper ratio are based on the exposed plan forms.

delete: ~~About 60 models were supplied by Boeing Airplane Co.~~ There were several models varying in stiffness and mass for each plan form. The basic structural member of the models was a laminated core made of six thin sheets of aluminum alloy or steel. The plan-form dimensions of each laminar of the core are shown in figure 3, and the sheet thickness and material for each model are indicated in table I. The airfoil shape was formed by bonding balsa to the core with the grain of the balsa oriented perpendicular to the core to minimize the effect of the balsa on the stiffness. The models were finished with a polyester type of plastic film. The models were equipped with two wire-strain-gage bridges oriented to be sensitive to bending and torsion strains.

The nacelles for the models were solid cylinders with conical ends. Each nacelle weighed about one-half as much as the wing and had its center of gravity at its center. The nacelles were fastened directly to the wing with two screws. The nacelle locations are shown in figure 1 and the nacelle mass properties are presented in table I.

The masses and natural vibration frequencies of the various models tested are presented in table I. Under the column heading, "Model," the letters "A, B, C, D, etc.," suffixed to the numerical designations indicate duplicate models of each design. The letter "N" suffixed to the model designation indicates that the model was tested with nacelles attached. Other suffixes are explained in the "Remarks" column.

Natural-vibration mode shapes were measured on models typical of the four configurations used in the flutter tests. The first three natural-vibration modes measured for models 2G and 2GN of the normal plan form and models 4E and 4EN of the extended plan form are presented in figures 4 to 7. The mode shapes are presented in the form of contours of constant amplitude. These contours were obtained by the acceleration method of reference 1.

Test Procedure

The test procedure used in the supersonic flutter tunnel was to establish the desired Mach number and then increase the test section density by increasing the stagnation pressure until flutter was observed. The procedure used in the transonic tunnel was somewhat different in that each flutter point was obtained at essentially constant stagnation pressure and the flutter condition was reached by increasing the speed.

For the tests in the supersonic tunnel the model strain-gage outputs as well as tunnel conditions were recorded for the entire run by utilizing an oscillograph. In the transonic tunnel the strain-gage outputs from the model were recorded continuously by using a magnetic tape recorder equipped with a frequency-modulation system.

RESULTS AND DISCUSSION

Flutter data were obtained at speeds up to $M = 3.0$. These data are presented in table I. Flutter curves are presented in figures 8 to 11, where the altitude-stiffness parameter $\frac{b\omega_\alpha}{a}\sqrt{\mu}$ is plotted against Mach number. This parameter has been useful in the past in interpreting data obtained from a variety of models, particularly when the behavior of the models is such that the stiffness required to prevent flutter varies as the dynamic pressure.

The altitude-stiffness parameters shown are based on the semichord b at the 0.75-span station. The value of b used was 0.165 foot for both plan forms. The frequency ω_α used in calculating values of the parameter is the measured frequency of the mode which most nearly resembled a first torsional mode. The mass-ratio parameter μ is defined as the ratio of the mass of the exposed model (including the nacelles when used) to the mass of the volume of air contained in the conical frustrum whose height is the exposed model span and whose bases have diameters equal to the root chord and the tip chord. For the normal plan form this volume was 0.073 cubic foot, whereas for the extended plan form this volume was 0.095 cubic foot.

In general, the trends indicated by the data in figures 8 to 11 are similar to the trends presented in references 2 and 3 in that continuously increasing stiffness or altitude is required for flutter-free operation at supersonic speeds for these low-aspect-ratio surfaces with highly swept leading edges. These curves show that a decrease in air density by a factor of about 4 is required to prevent flutter in changing the Mach number from 1.3 to 3.0.

An indication of the effect of the nacelles is difficult to determine from the data presented in the form of the stiffness-altitude parameter. Consequently, the data have been replotted in figure 12 in the form of the ratio of the dynamic pressure required for flutter with nacelles to the dynamic pressure required without nacelles (base wing). Most of the data fall above a ratio of 1.0 with only 3 points falling slightly below 1.0, indicating that the effect of the nacelles was, in general, beneficial.

The models as designed were too stiff to flutter in the Langley 2-foot transonic flutter tunnel; however, when the plastic film coating was removed from one of the extended-plan-form models, flutter was obtained with nacelles attached up to a Mach number near 1.0. Beyond a Mach number of 1.0, this model experienced a type of static divergence which appeared to be due to the localized weakening of the leading edge. With the nacelles removed this divergence condition was encountered at dynamic pressures below the dynamic pressure required for flutter with the nacelles attached. These divergence characteristics are indicated in figure 13 where the dynamic pressure at the flutter or divergence boundary is shown as a function of Mach number for a model of the extended plan form with and without the nacelles. The bare wing diverged at a nearly constant value of dynamic pressure at Mach numbers from about 0.7 to 1.2 while the wing with nacelles fluttered or diverged at appreciably higher values of dynamic pressure. The increase in the dynamic pressure required for divergence of the wing with nacelles may have been due to a stiffening effect of the nacelles.

CONCLUDING REMARKS

As a result of wind-tunnel flutter tests up to Mach number 3.0, it appears that the nacelles of the configurations tested impose no flutter penalty; in fact, the dynamic pressure required to flutter a wing with nacelles was generally higher than that required to flutter the bare wing.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., September 27, 1957.

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2. Tuovila, W. J., and McCarty, John Locke: Experimental Flutter Results for Cantilever-Wing Models at Mach Numbers up to 3.0. NACA RM L55E11, 1955.

3. Garrick, I. E.: Some Concepts and Problem Areas in Aircraft Flutter. S.M.F. Fund Paper No. FF-15, Inst. Aero. Sci., Mar. 1957.

TABLE I.- MODEL DATA

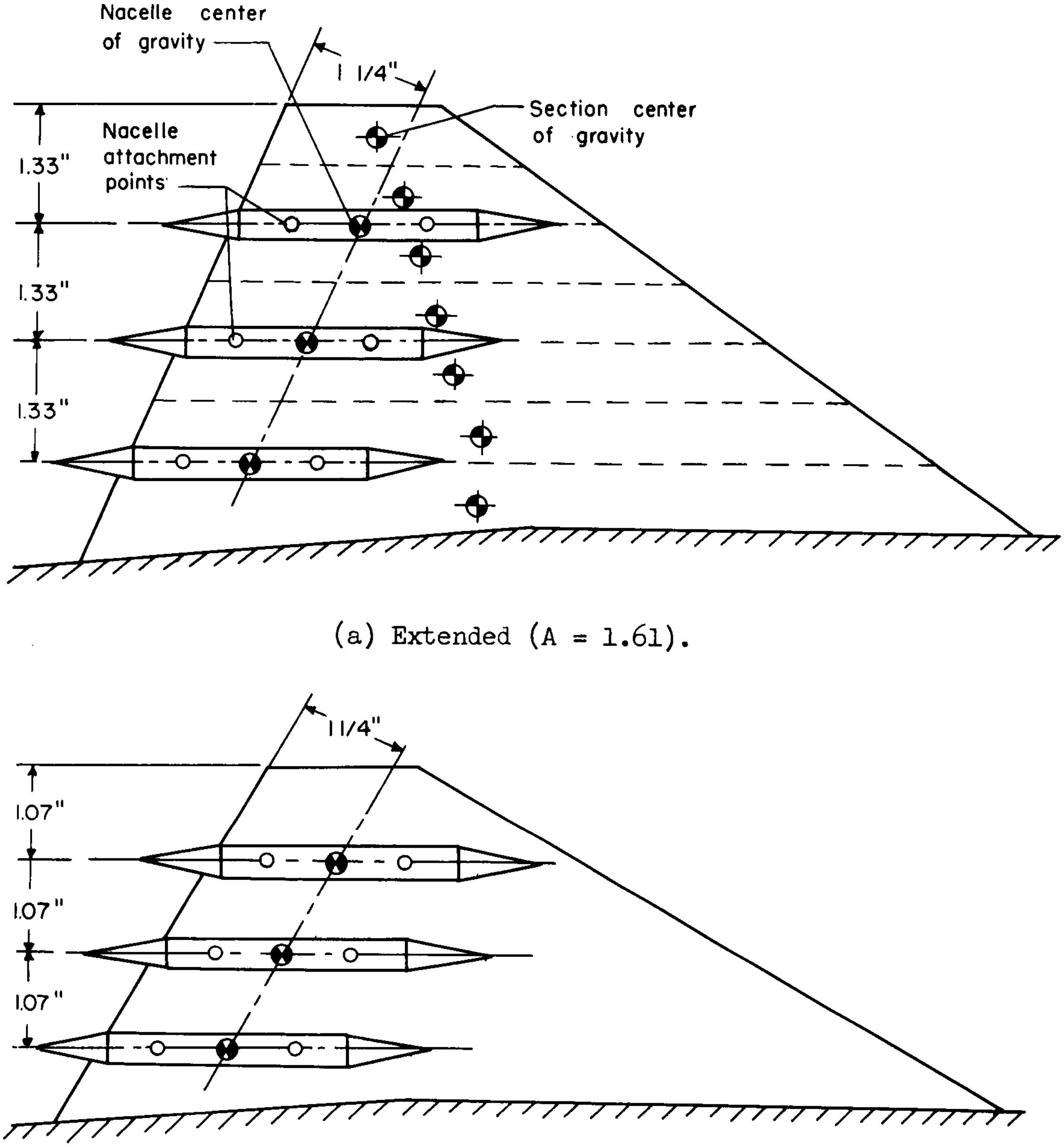
(a) Normal plan form

Model	Core, each lamina		Wing weight, lb	Each nacelle		M	Frequency, cps				a	q	ρ	μ	$\frac{b\omega_\alpha}{a}\sqrt{\mu}$	Remarks
	Thickness, in.	Material		Weight, lb	Inertia, in-lb/sec^2		f_{h_1}	f_α	f_{h_2}	f_f						
2B	0.006	Steel	0.13	-------	------------	0.74	148	280	400	182	1072	1075	0.00330	16.75	1.105	---------------
2BN	.006	Steel	.13	0.0735	12.85 x 10^{-5}	.74	71	162	267	---	1077	1807	.00549	27.1	.313	No flutter
2B	.006	Steel	.13	-------	------------	1.30	147	273	391	191	988	1215	.00149	37.1	1.743	---------------
2BN	.006	Steel	.13	.0735	12.85	1.30	71	162	260	99	992	2240	.00267	55.7	1.26	---------------
2B	.006	Steel	.13	-------	------------	1.64	149	272	388	200	933	1520	.00130	42.5	1.970	---------------
2B	.006	Steel	.13	-------	------------	2.00	147	280	470	199	869	1519	.00100	55.4	2.48	---------------
2B	.006	Steel	.13	-------	------------	3.00	147	280	400	195	713	1732	.000755	73.2	3.48	---------------
2IX	.006	Steel	.116	-------	------------	.65	127	227	318	---	1128	1263	.00471	10.5	.672	No flutter
2IX	.006	Steel	.116	-------	------------	1.30	126	232	325	155	982	615	.00075	65.8	1.978	No plastic skin on model 2IX
2IX	.006	Steel	.116	-------	------------	1.64	129	229	320	167	923	650	.00057	86.6	2.355	
2IX	.006	Steel	.116	-------	------------	2.00	128	218	350	160	855	840	.000464	106.5	2.72	
2IX	.006	Steel	.116	-------	------------	3.00	129	217	358	152	697	633	.000289	171.0	4.21	
2F	.006	Steel	.13	-------	------------	1.06	160	290	388	200	1043	1343	.00221	25.0	1.435	---------------
2FN	.006	Steel	.13	.0735	12.85	1.10	76	167	275	102	1040	1573	.00242	61.5	1.30	---------------
2J	.006	Steel	.126	-------	------------	.85	157	300	425	195	1073	1494	.00361	14.85	1.11	---------------
2JN	.006	Steel	.126	.0735	12.85	.87	76	180	285	---	1100	2687	.00593	24.8	.84	No flutter
3A	.004	Steel	.092	-------	------------	1.30	139	298	391	180	981	1375	.00166	23.6	1.520	---------------
3B	.004	Steel	.090	-------	------------	1.30	121	282	406	188	986	1242	.00151	25.4	1.483	---------------
3BN	.004	Steel	.090	.050	8.2	1.30	62	166	252	104	992	1720	.00206	49.5	1.22	---------------
3B	.004	Steel	.090	-------	------------	1.64	122	275	400	200	932	1610	.00137	28.0	1.62	---------------
3BN	.004	Steel	.090	.050	8.2	1.64	67	180	281	114	928	2082	.001803	56.7	1.51	---------------
3B	.004	Steel	.090	-------	------------	2.00	130	291	409	200	873	1980	.00131	29.2	1.86	---------------
3BN	.004	Steel	.090	.050	8.2	2.00	66.7	183	284	108	875	2080	.00136	75.0	1.87	---------------
3B	.004	Steel	.090	-------	------------	3.00	138	292	505	195	739	2228	.000905	42.4	2.66	---------------
3BN	.004	Steel	.090	.050	8.2	3.00	68.2	181	289	100	723	2150	.000910	112.3	2.74	---------------
3D	.004	Steel	.088	-------	------------	3.00	136	284	400	176	725	1554	.000656	57.0	3.06	---------------
1BB	.010	Aluminum	.097	-------	------------	.63	198	370	523	---	1107	1291	.00531	7.77	.964	No flutter
1BB	.010	Aluminum	.097	-------	------------	1.64	195	371	500	250	941	1968	.00165	25.0	2.035	---------------
1CC	.010	Aluminum	.093	-------	------------	1.64	197	352	480	320	929	1375	.00118	33.5	2.27	---------------
1CCN	.010	Aluminum	.093	.0514	7.4	1.64	96	210	323	142	943	2180	.00181	58.4	1.76	---------------
9	.010	Aluminum	.070	-------	------------	1.64	171	269	340	220	914	469	.000416	71.5	2.58	Bare core
11	.010	Aluminum	.086	-------	------------	1.64	164	284	380	210	920	756	.000662	55.3	2.38	No plastic skin
13A	.007	Steel	.146	-------	------------	1.64	161	280	394	215	928	1481	.001265	49.0	2.183	---------------
13AN	.007	Steel	.146	.0735	12.85	1.64	92	200	312	141	947	2780	.00230	67.8	1.800	---------------
16B	.003	Steel	.078	-------	------------	.65	119	250	359	164	1098	762	.00300	11.05	.783	---------------
16BN	.003	Steel	.078	.050	8.2	.65	57	150	228	---	1110	1464	.00569	17.1	.578	No flutter
16D	.003	Steel	.078	-------	------------	.85	135	287	410	167	1082	1575	.00368	9.02	.822	---------------
16EE	.003	Steel	.078	-------	------------	.63	117	259	404	---	1113	1307	.00532	6.24	.60	No flutter
16EE	.003	Steel	.078	-------	------------	.74	118	259	404	162	1072	1007	.00309	10.75	.818	---------------
3E	.004	Steel	.090	-------	------------	3.00	129	245	429	167	712	1159	.000506	75.5	3.09	---------------

TABLE I.- MODEL DATA - Concluded

(b) Extended plan form

Model	Core, each lamina		Wing weight, lb	Each nacelle		M	Frequency, cps				a	q	ρ	μ	$\frac{b\omega_\alpha}{a}\sqrt{\mu}$	Remarks
	Thickness, in.	Material		Weight, lb	Inertia, in-lb/sec^2		f_{h_1}	f_α	f_{h_2}	f_f						
8A	0.012	Aluminum	0.146	-------	------------	0.68	140	299	412	169	1115	928	0.00322	14.8	1.07	------------------
8AN	.012	Aluminum	.146	0.0735	12.45 × 10^{-5}	.65	72	174	276	---	1110	1462	.00564	21.2	.471	No flutter
8A	.012	Aluminum	.146	-------	------------	.85	135	283	410	175	1073	1127	.00273	17.5	1.137	------------------
8A	.012	Aluminum	.146	-------	------------	1.10	132	283	403	167	1031	918	.00142	33.6	1.650	------------------
8AN	.012	Aluminum	.146	.0735	12.45	1.10	68	171	261	111	1036	992	.00154	77.6	1.583	------------------
8A	.012	Aluminum	.146	-------	------------	1.30	147	301	432	200	991	1402	.00168	28.4	1.673	------------------
8AN	.012	Aluminum	.146	.0735	12.45	1.30	75	187	281	110	978	1555	.00191	62.6	1.56	------------------
8A	.012	Aluminum	.146	-------	------------	1.64	147	300	506	211	940	1637	.00138	34.6	1.937	------------------
8AN	.012	Aluminum	.146	.0735	12.45	1.64	77	186	286	120	932	2022	.001730	69.2	1.72	------------------
8A	.012	Aluminum	.146	-------	------------	2.00	150	305	435	212	870	1962	.001295	36.8	2.195	------------------
8AN	.012	Aluminum	.146	.0735	12.45	2.00	77	189	288	111	875	1905	.00125	95.7	2.18	------------------
4CN	.010	Aluminum	.122	.0659	9.29	2.00	58	162	236	100	870	1747	.00116	90.0	1.83	------------------
4C	.010	Aluminum	.122	-------	------------	3.00	126	265	375	185	714	1431	.000619	64.5	3.08	------------------
4CN	.010	Aluminum	.122	.0659	9.29	3.00	60	164	240	100	722	1815	.000773	135.0	2.72	------------------
4D	.010	Aluminum	.132	-------	------------	1.30	121	263	368	168	985	867	.00105	41.0	1.767	------------------
4DN	.010	Aluminum	.132	.0659	9.29	1.30	64	155	236	92	991	1060	.00126	85.4	1.49	------------------
4D	.010	Aluminum	.132	-------	------------	1.64	123	264	370	183	926	1116	.000968	44.5	1.93	------------------
4DN	.010	Aluminum	.132	.0659	9.29	1.64	67	164	248	107	930	1322	.00114	94.3	1.77	------------------
4D	.010	Aluminum	.132	-------	------------	2.00	125	267	375	200	866	1480	.000985	43.8	2.105	------------------
4DN	.010	Aluminum	.132	.0659	9.29	2.00	66.7	166	250	107	867	1612	.00107	100.0	1.98	------------------
5B	.006	Steel	.196	-------	------------	1.64	92	200	329	133	930	1000	.000861	74.3	1.912	------------------
5B	.006	Steel	.196	-------	------------	2.00	90	201	339	138	861	1228	.000826	77.5	2.12	------------------
5BN	.006	Steel	.196	.106	15.93	2.00	43.5	121	177	70	875	2045	.00134	157.0	1.79	------------------
5B	.006	Steel	.196	-------	------------	3.00	97	208	347	134	719	1395	.000600	107.0	3.10	------------------
5BN	.006	Steel	.196	.106	15.93	3.00	45	122	175	70	724	1835	.000777	216.0	2.56	------------------
8F	.012	Aluminum	.140	-------	------------	1.64	140	285	400	211	925	1580	.00136	33.6	1.85	------------------
8FTN	.012	Aluminum	.140	.0735	12.45	1.30	71	167	260	100	990	1339	.001615	72.9	1.49	
8FT	.012	Aluminum	.140	-------	------------	1.64	162	298	426	210	926	1790	.00154	29.6	1.81	Tip altered
8FTN	.012	Aluminum	.140	.0735	12.45	1.64	72	166	267	109	912	1680	.001485	79.3	1.675	
14A	.007	Steel	.185	-------	------------	1.64	109	220	313	155	928	1318	.00113	53.5	1.790	------------------
14AN	.007	Steel	.185	.106	15.93	1.64	50	130	185	70	929	1628	.00142	115.7	1.56	------------------
10	.010	Aluminum	.079	-------	------------	1.64	99	183	238	-----	911	450	.00040	64.5	1.67	Bare core, diverged
12	.010	Aluminum	.098	-------	------------	1.64	97	202	257	145	911	402	.000356	90.0	2.18	No plastic skin
						.77	26.1	81.4	102.4	39.9	512	217	.00273	37.2	1.00	
						.75	26.1	81.4	102.4	42.0	508	211	.00283	35.9	.99	
						.68	26.1	81.4	102.4	42.8	511	211	.00339	30.0	.90	
						.64	26.1	81.4	102.4	42.4	513	216	.00407	25.0	.82	
						.60	26.1	81.4	102.4	43.7	514	216	.00458	22.2	.77	
						.91	26.5	81.8	102.3	36.5	507	158	.00144	70.4	1.40	
						.91	26.5	81.8	102.3	37.0	507	164	.00150	67.6	1.37	
6DNX	.004	Steel	.113	.0659	9.29	.87	26.5	81.8	102.3	37.8	508	171	.00170	59.7	1.28	No plastic skin
						.81	26.5	81.8	102.3	39.1	510	173	.00201	50.7	1.18	
						.79	26.5	81.8	102.3	40.0	509	187	.00229	44.5	1.11	
						.73	26.5	81.8	102.3	40.6	509	193	.00273	37.3	1.01	
						1.05	27.2	83.0	105.0	-----	502	172	.00120	84.6	1.57	Diverged
						.99	27.2	83.0	105.0	35.4	503	162	.00128	79.6	1.52	
						1.12	27.2	83.0	105.0	-----	501	164	.00102	99.2	1.70	Diverged
						.62	27.0	81.6	101.0	43.5	502	201	.00406	25.0	.84	

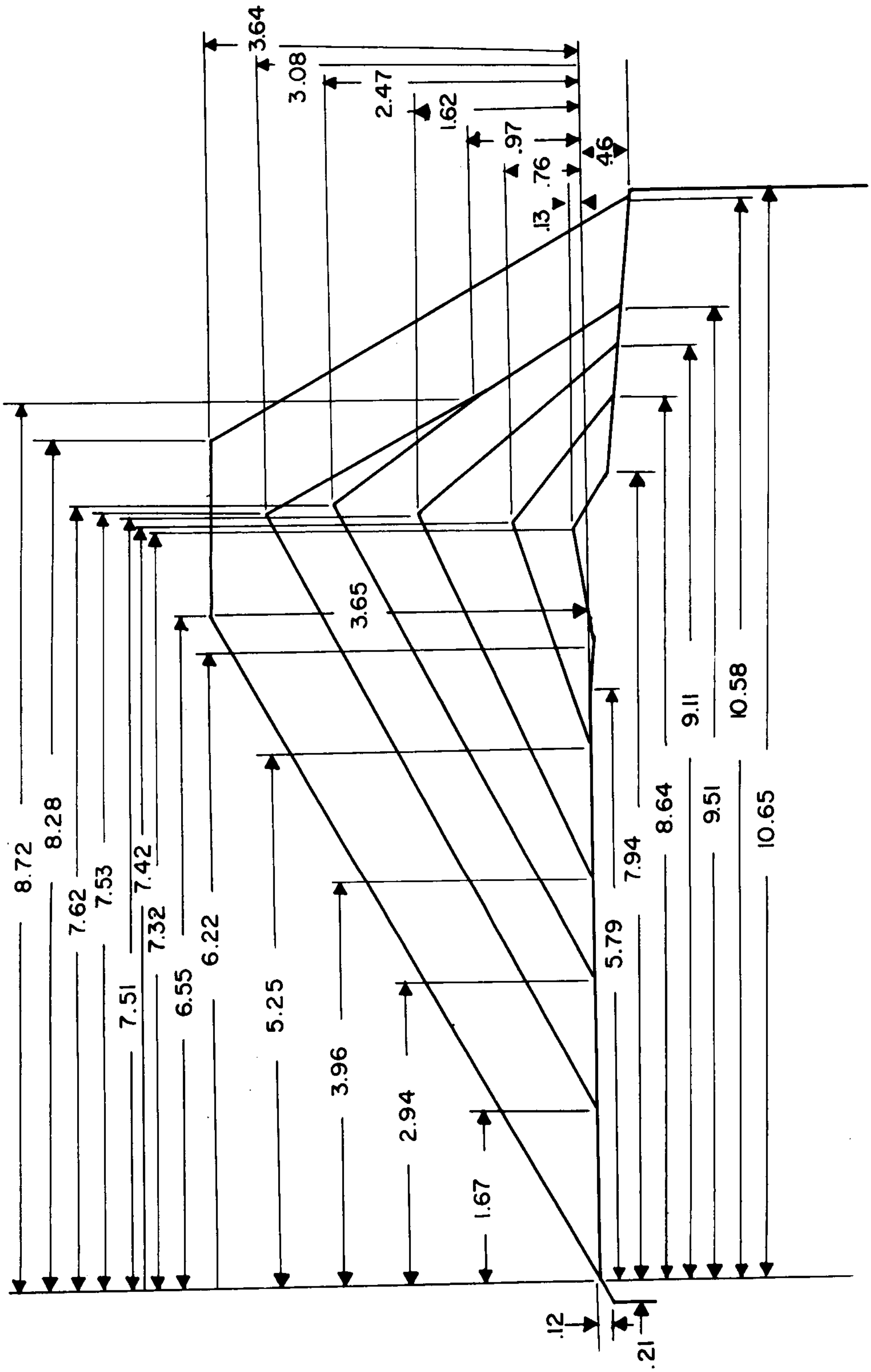


(a) Extended (A = 1.61).

(b) Normal (A = 1.27).

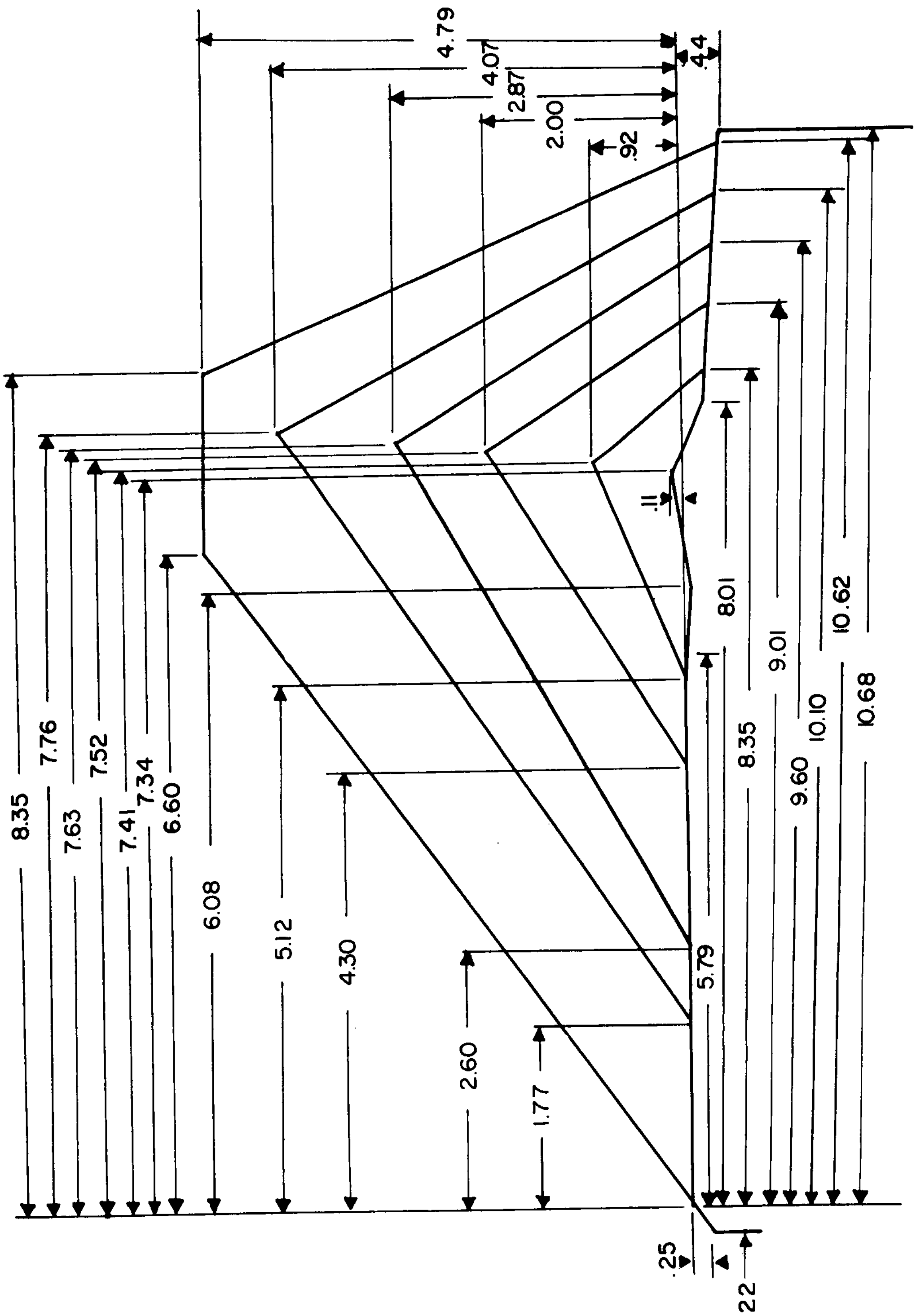
Figure 1.- Model plan forms.

L-57-1916
Figure 2.- Extended plan form with nacelles mounted in Langley 2-foot transonic flutter tunnel.



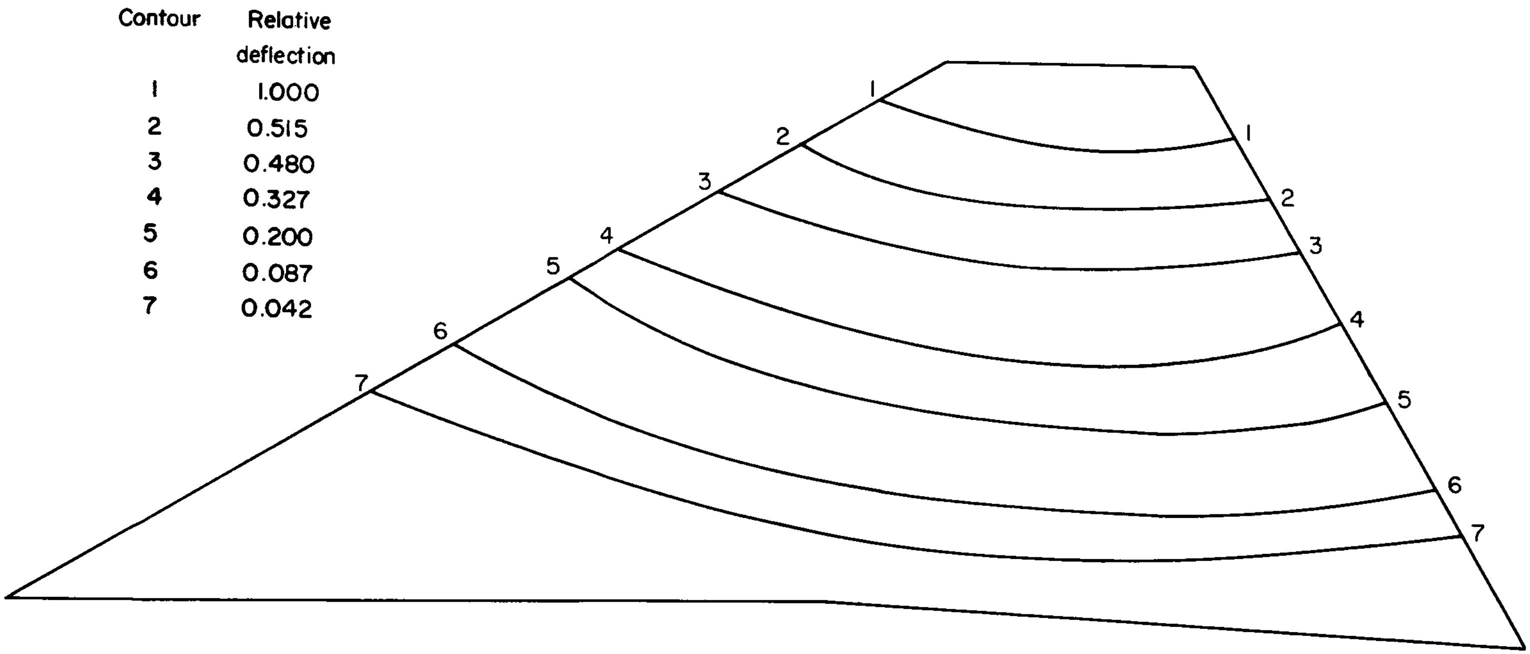
(a) Normal plan form.

Figure 3.- Core lamination.



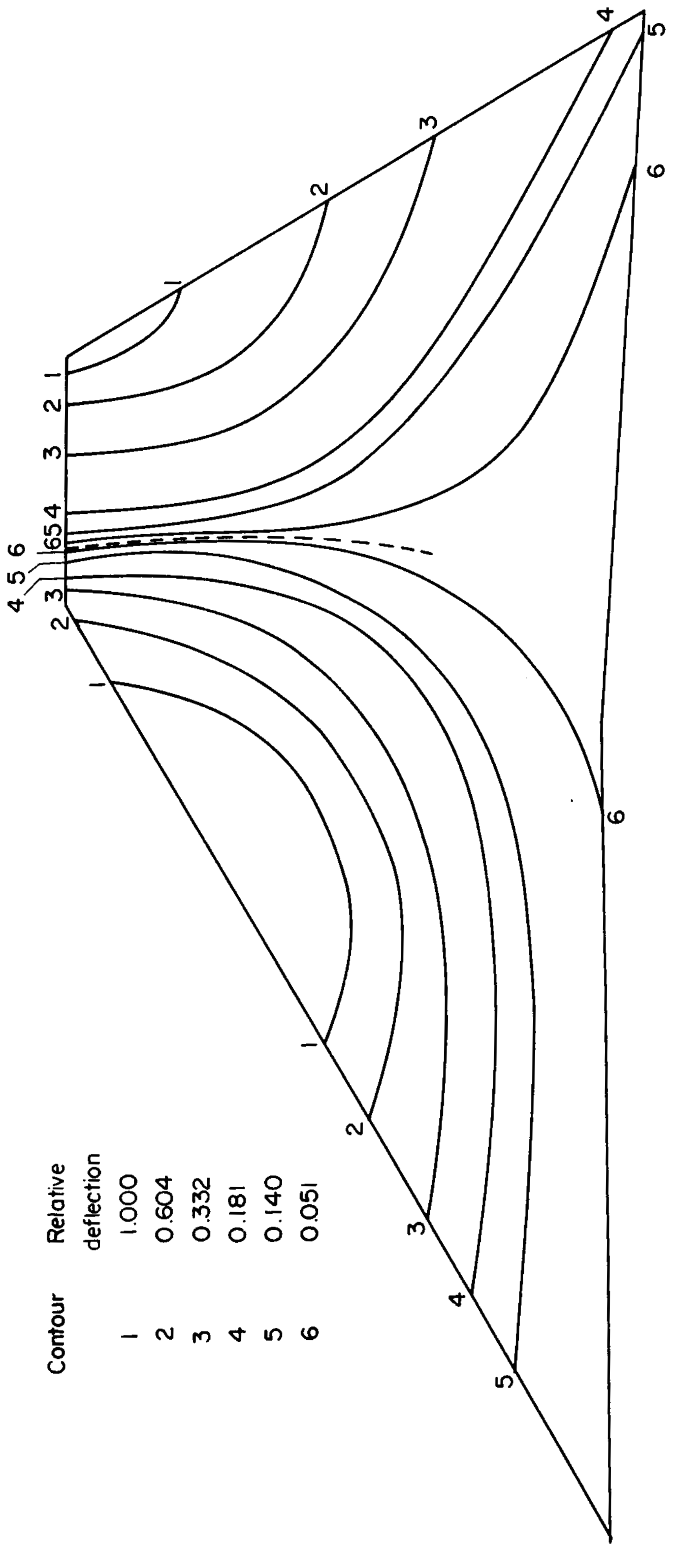
(b) Extended plan form.

Figure 3.- Concluded.



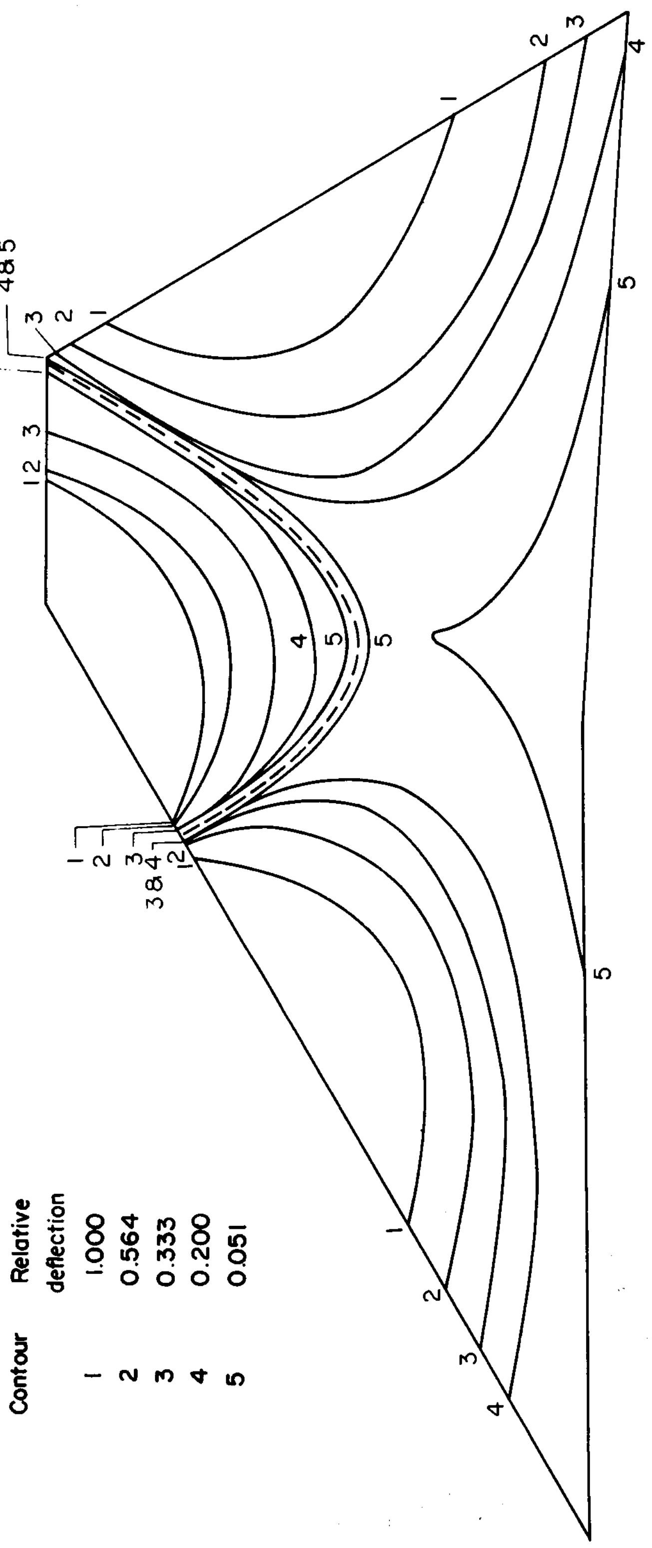
(a) First mode; $f_{h_1} = 155$ cps.

Figure 4.- Natural-vibration-mode shapes for model 2G. Normal plan form.



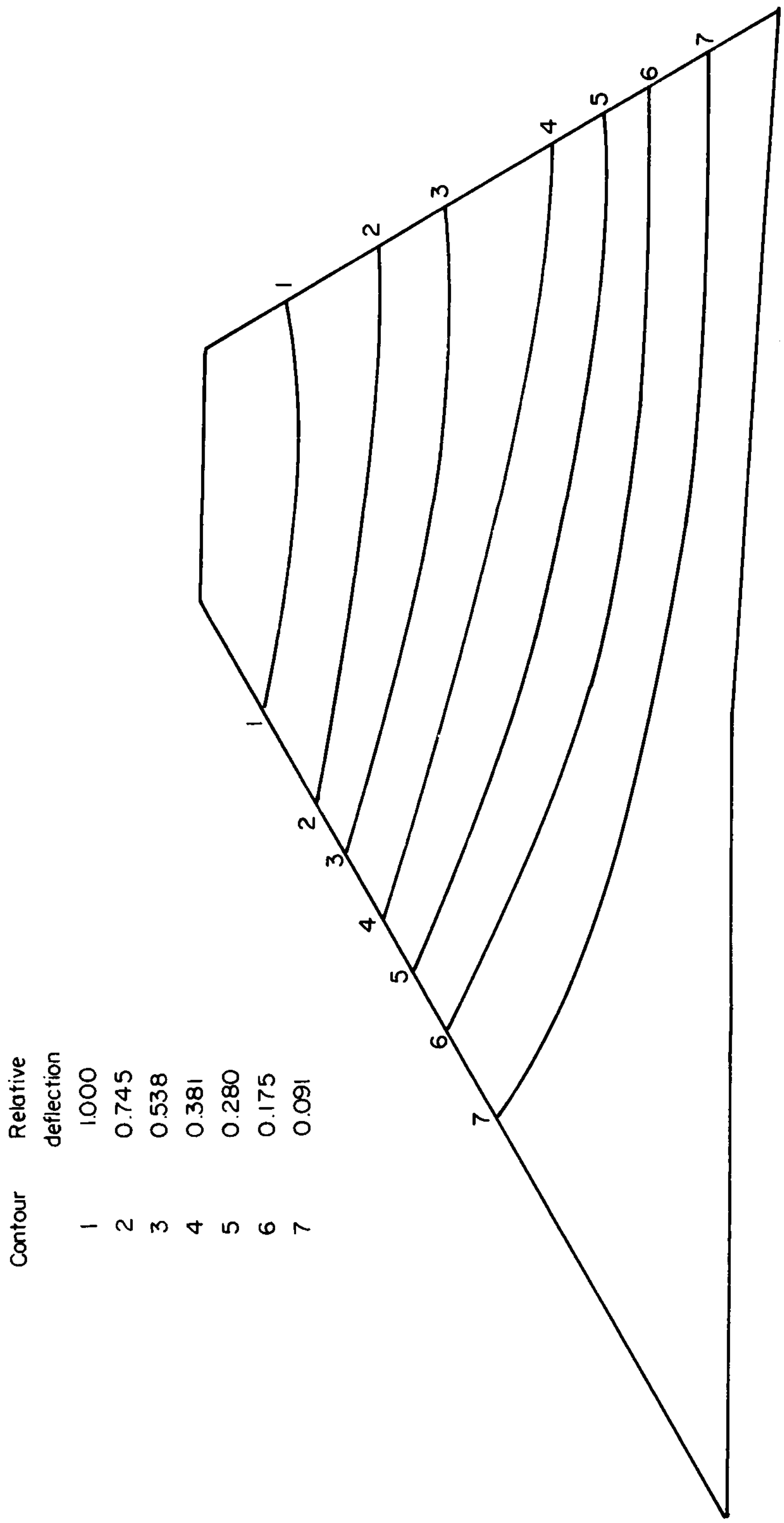
(b) Second mode; $f_{\alpha_1} = 294$ cps.

Figure 4.- Continued.



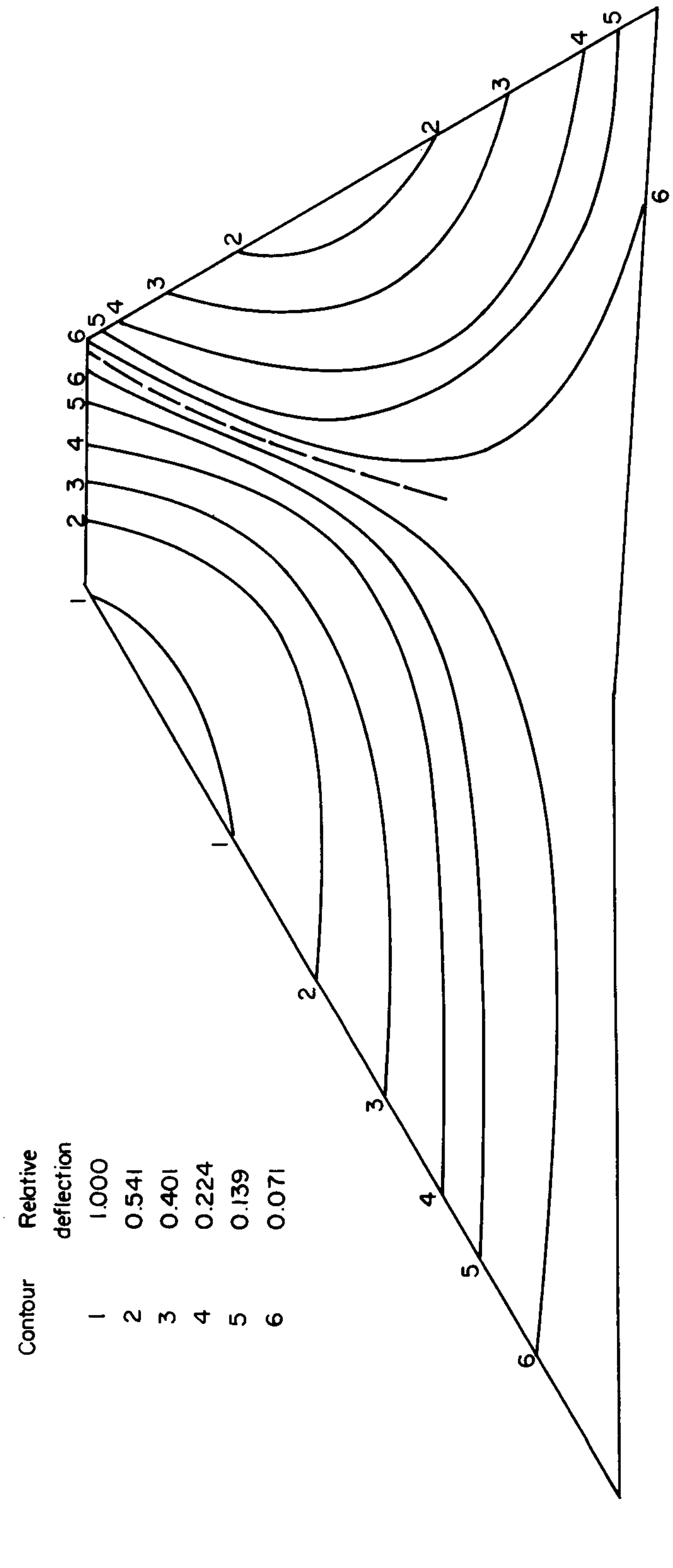
(c) Third mode; f_{h_2} = 422 cps.

Figure 4.- Concluded.



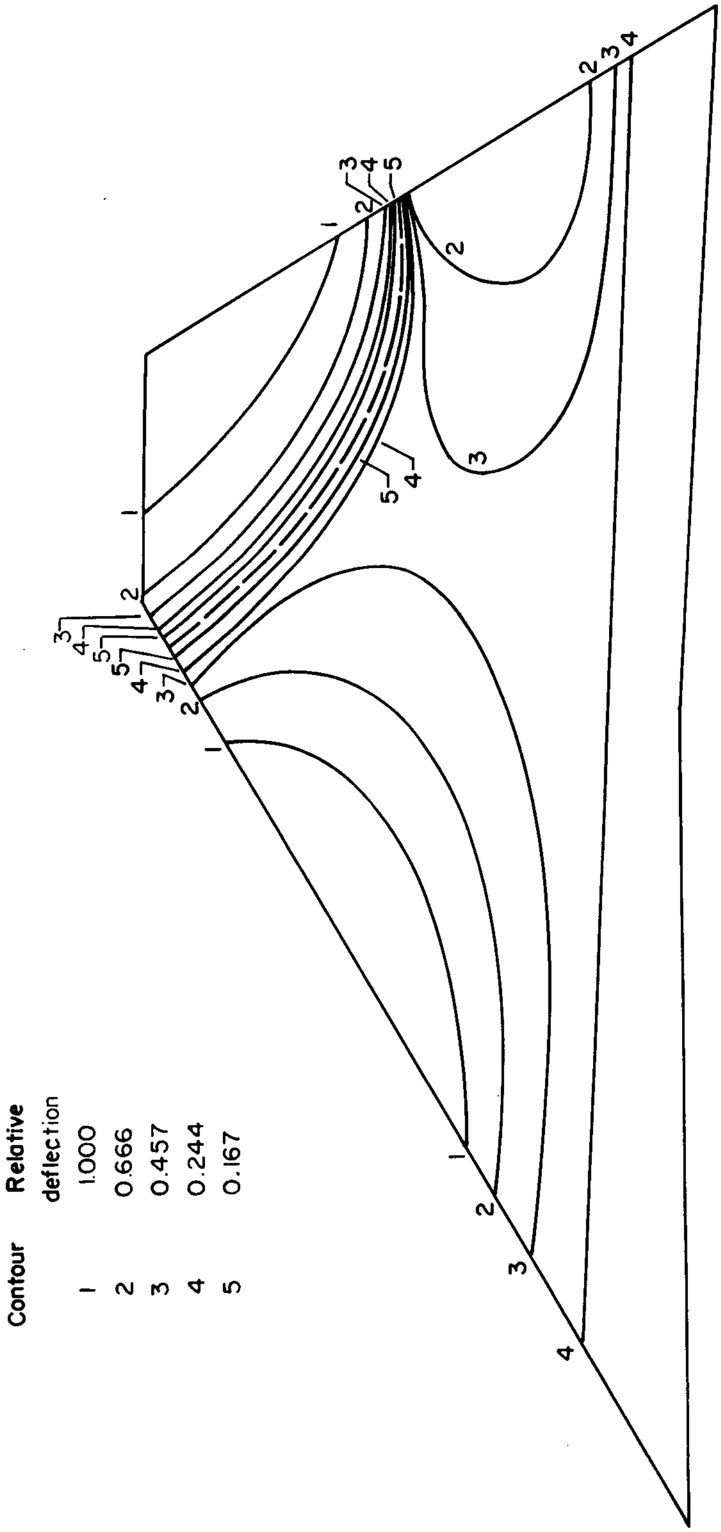
(a) First mode; $f_{h_1} = 78$ cps.

Figure 5.- Natural-vibration-mode shapes for model 2GN. Normal plan form.



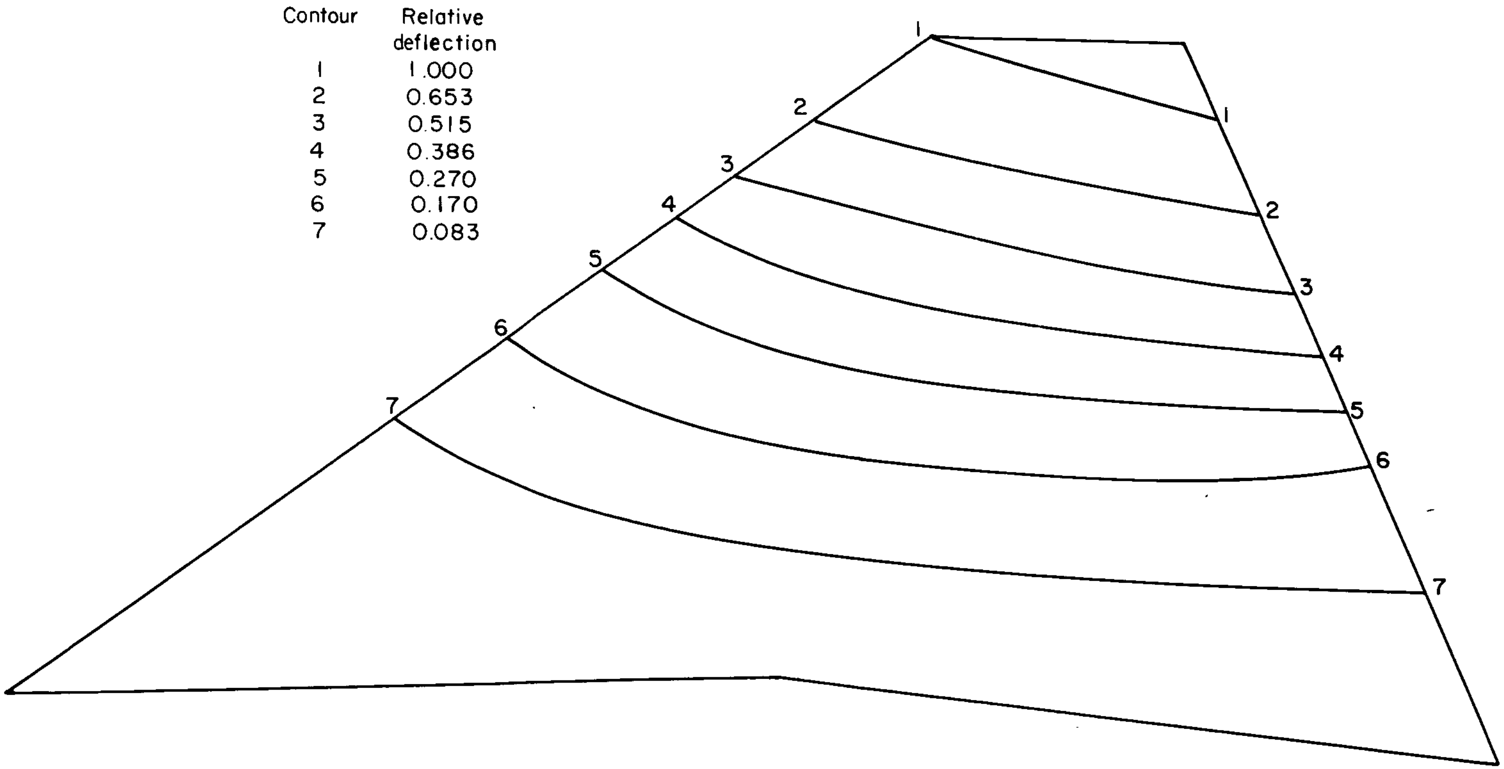
(b) Second mode; $f_{\alpha_1} = 188$ cps.

Figure 5.- Continued.



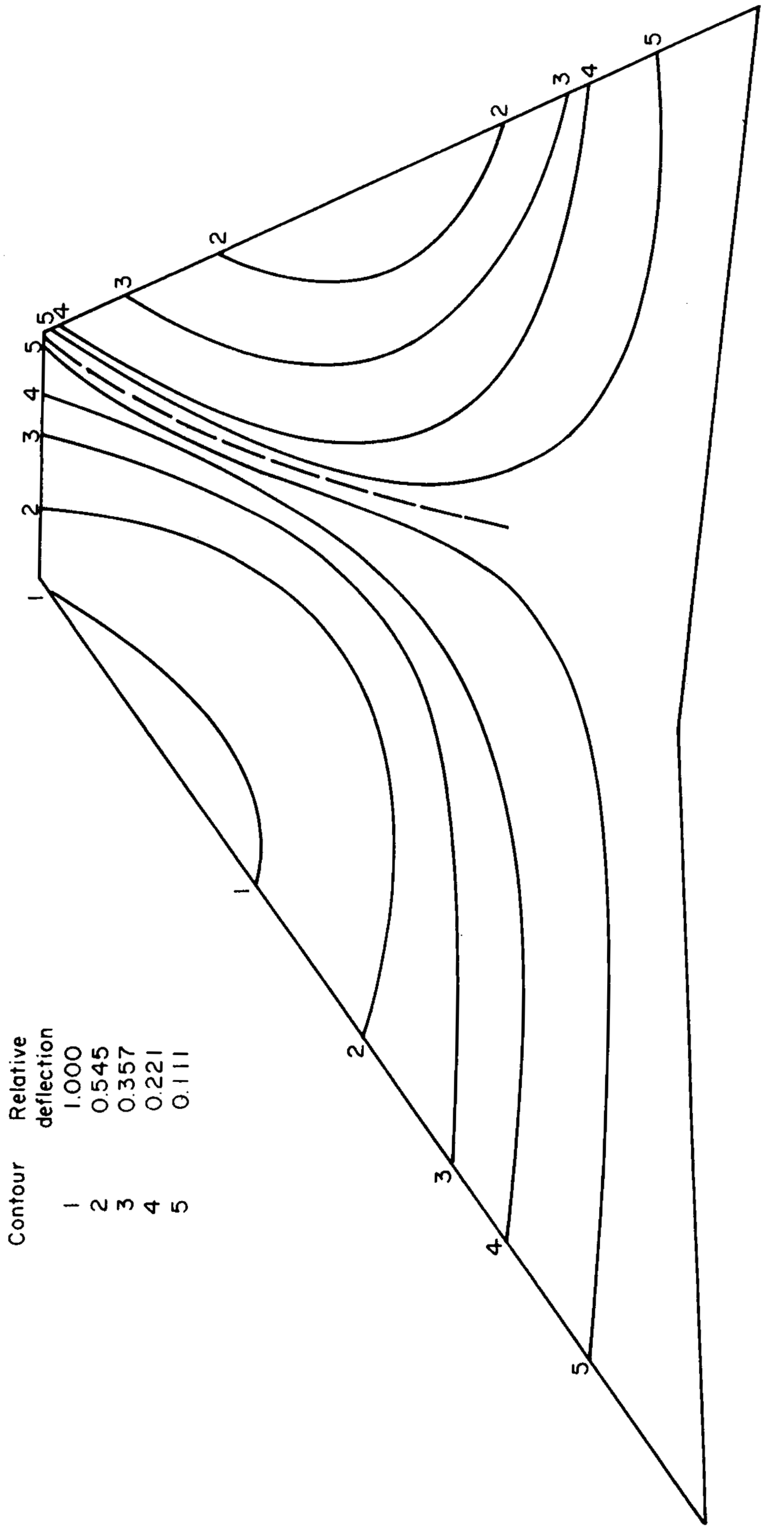
(c) Third mode; f_{h_2} = 284 cps.

Figure 5.- Concluded.



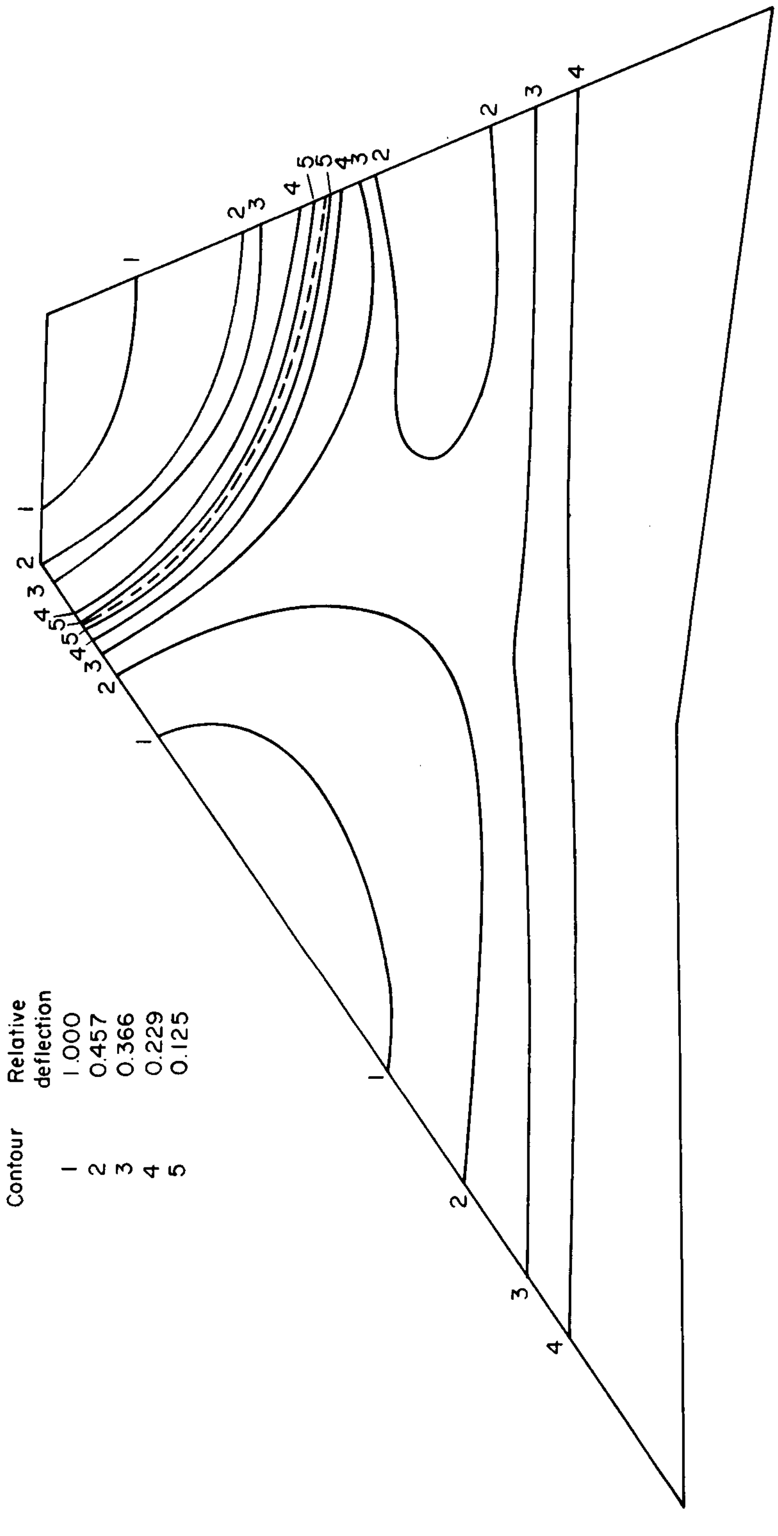
(a) First mode; $f_{h_1} = 66.5$ cps.

Figure 6.- Natural-vibration-mode shapes for model 4EN. Extended plan form.



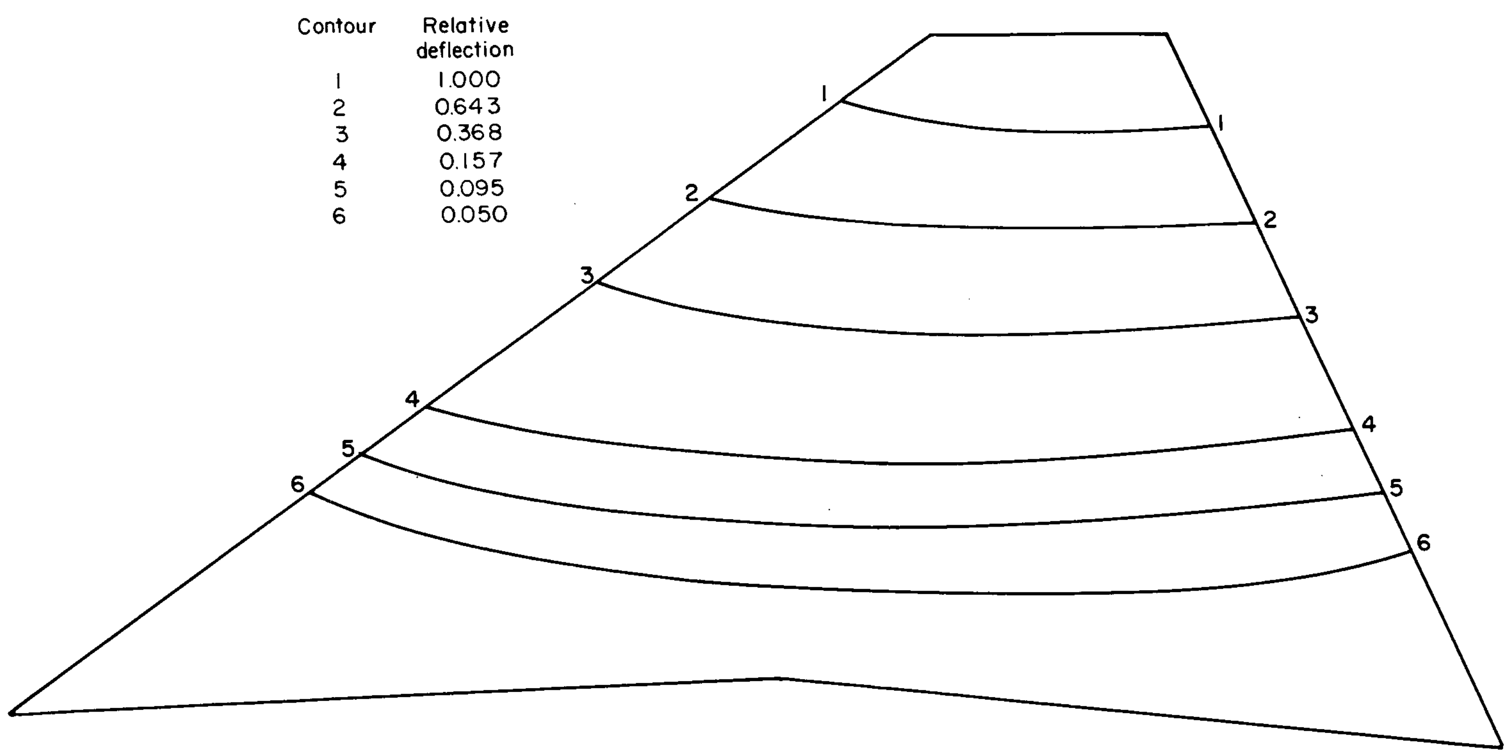
(b) Second mode; f_{α_1} = 135 cps.

Figure 6.- Continued.



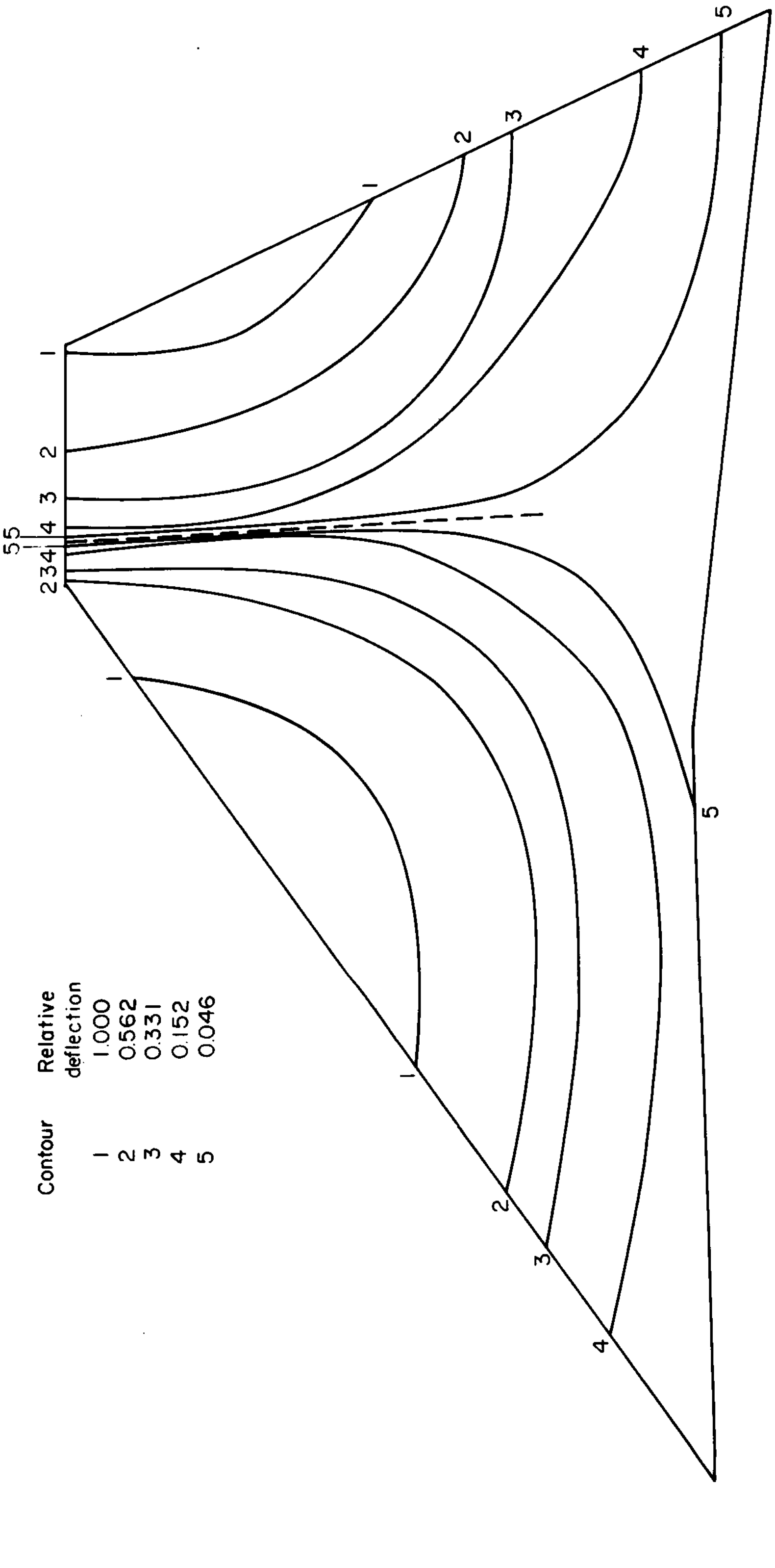
(c) Third mode; f_{h_2} = 260 cps.

Figure 6.- Concluded.



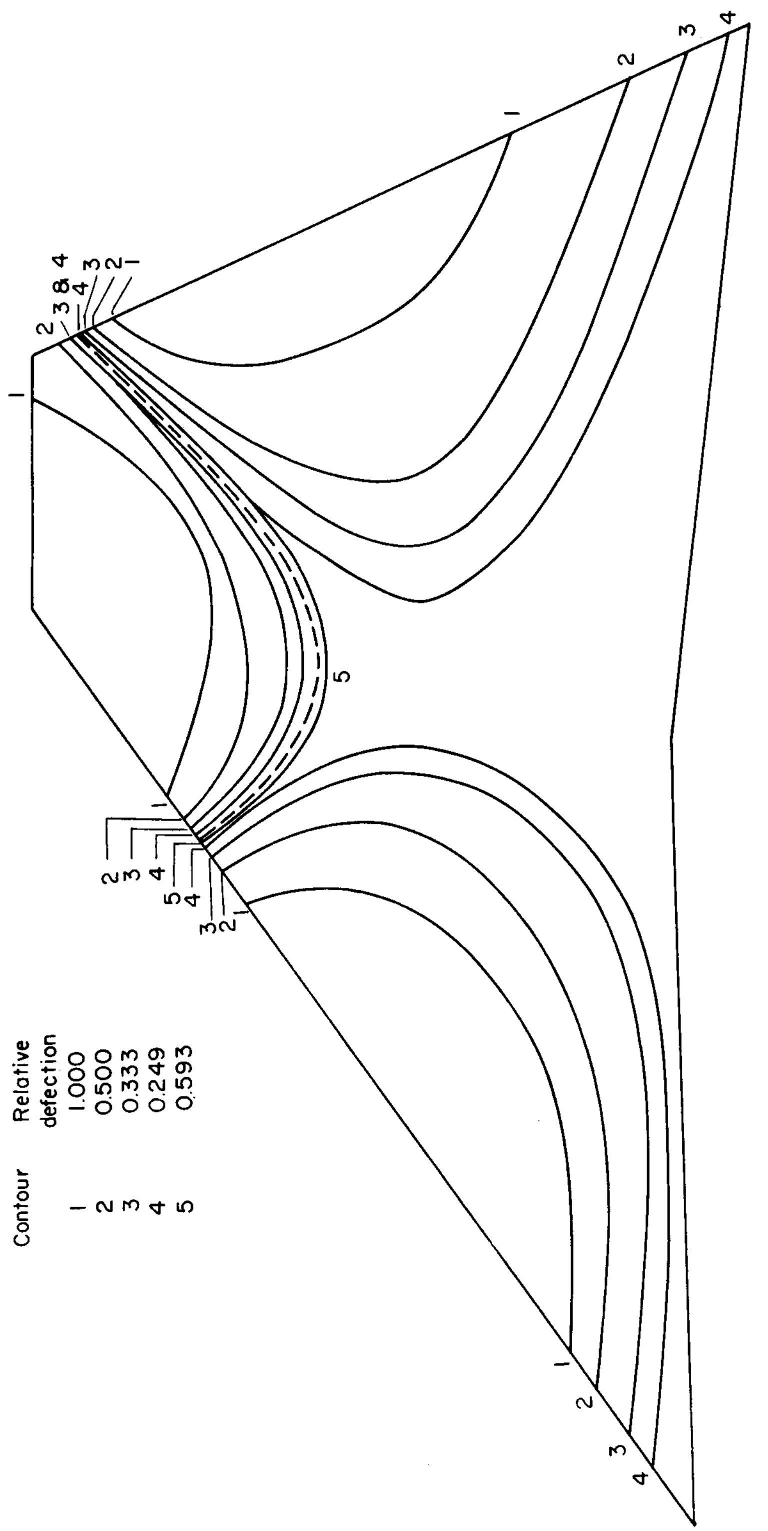
(a) First mode; $f_{h_1} = 124$ cps.

Figure 7.- Natural-vibration-mode shapes for model 4E. Extended plan form.



(b) Second mode; $f_{\alpha_1} = 270$ cps.

Figure 7.- Continued.



(c) Third mode; f_{h_2} = 392 cps.

Figure 7.- Concluded.

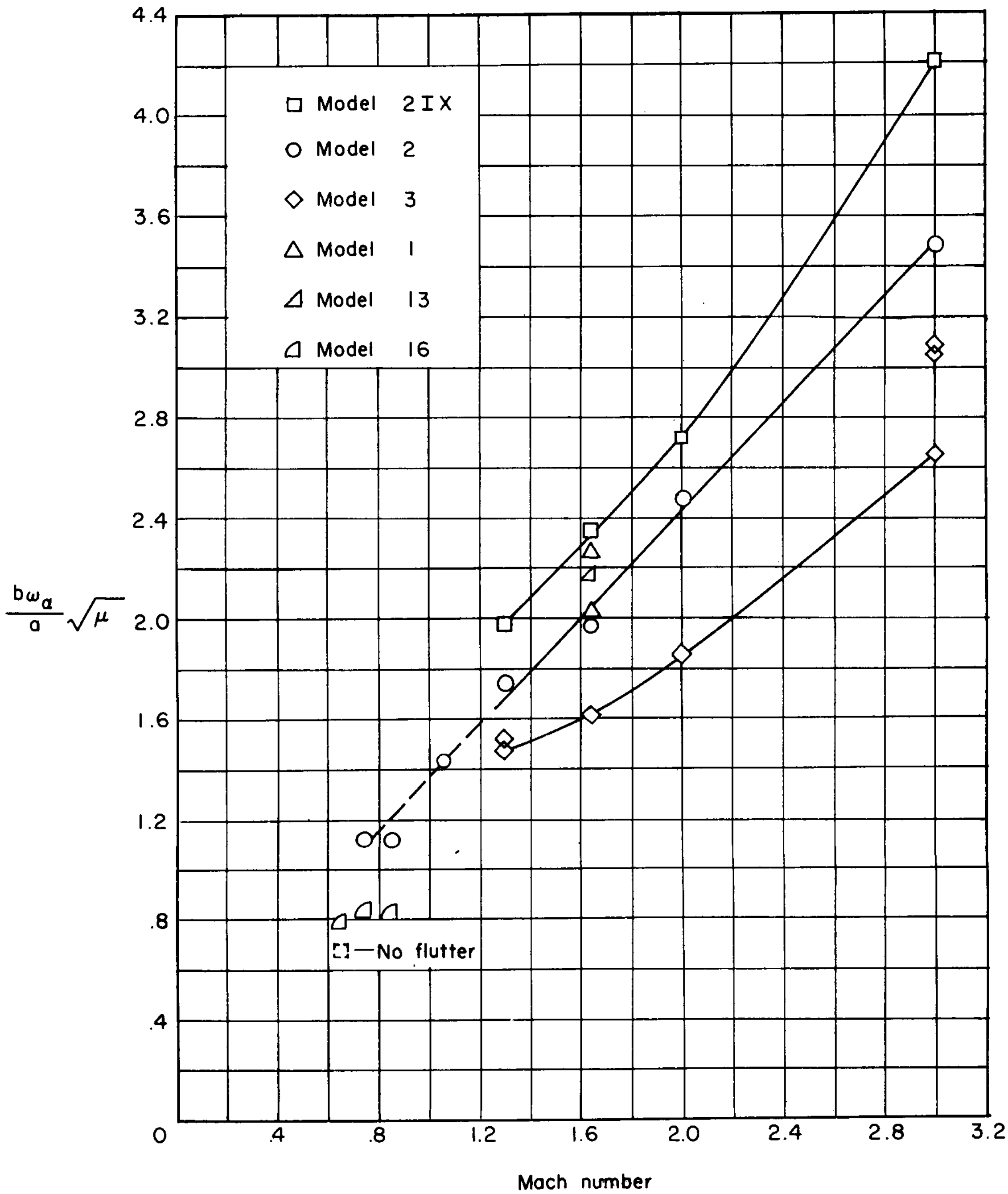


Figure 8.- Flutter curves for normal-plan-form models without nacelles.

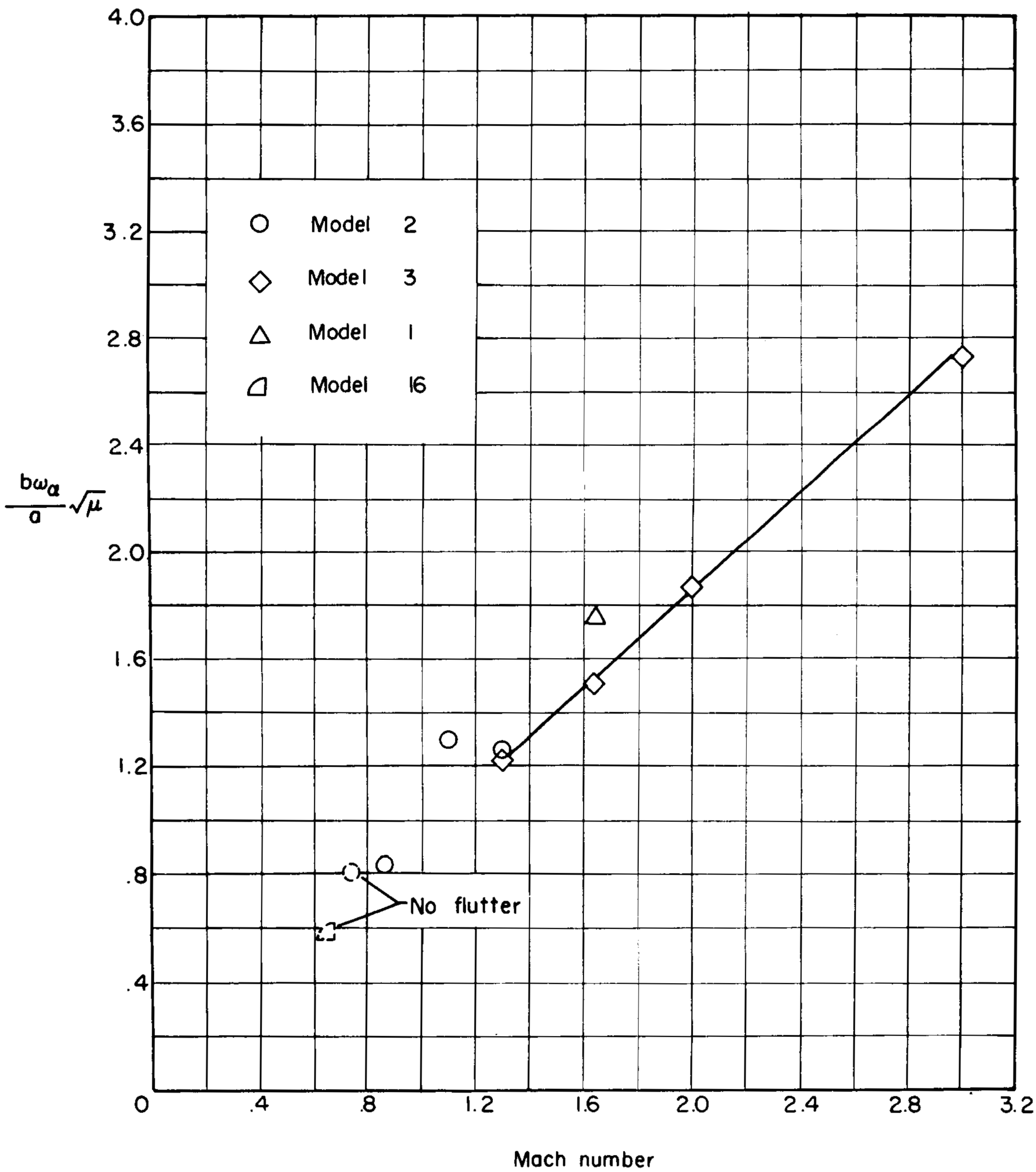


Figure 9.- Flutter curves for normal-plan-form models with nacelles.

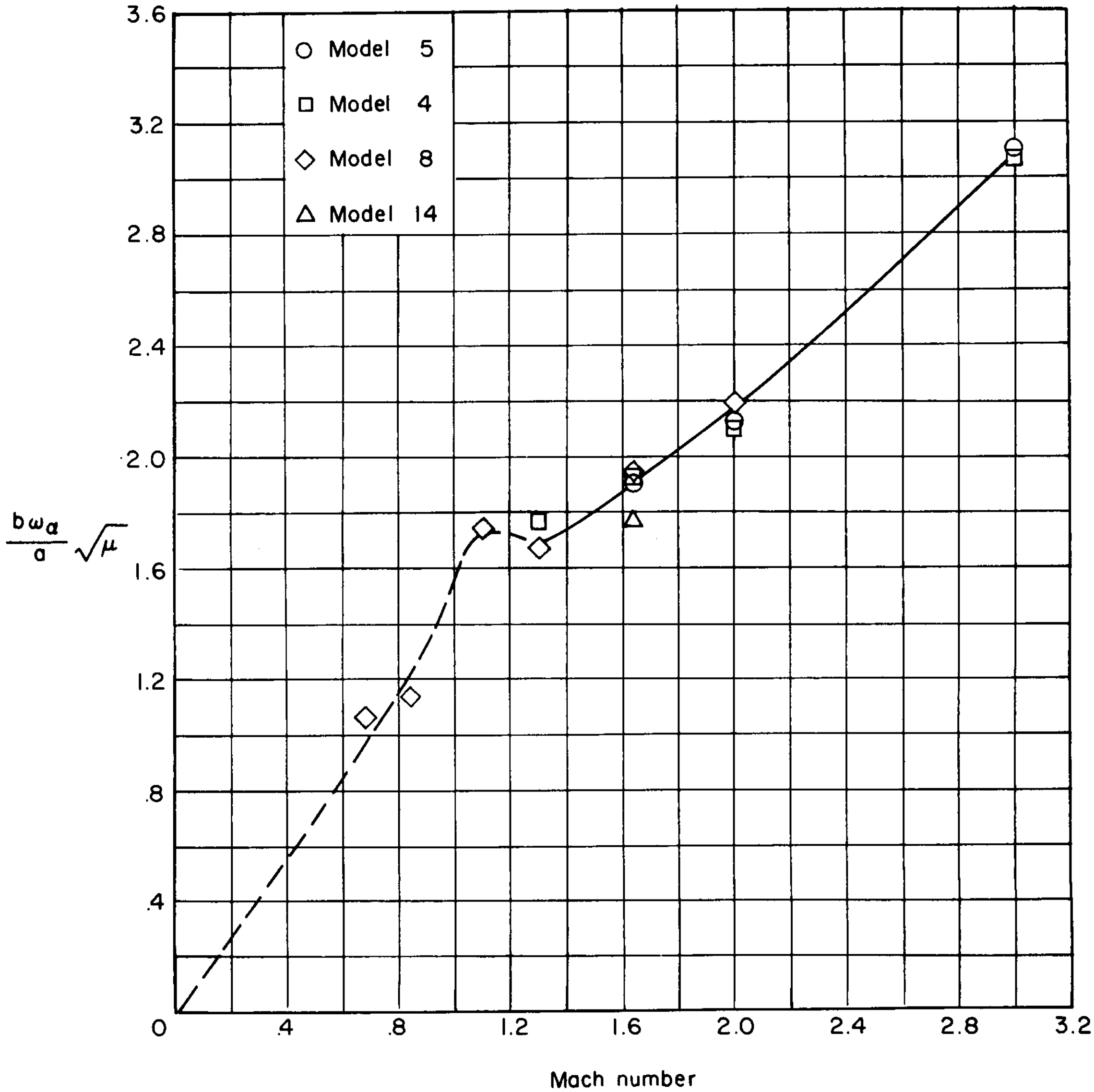


Figure 10.- Flutter curves for extended-plan-form models without nacelles.

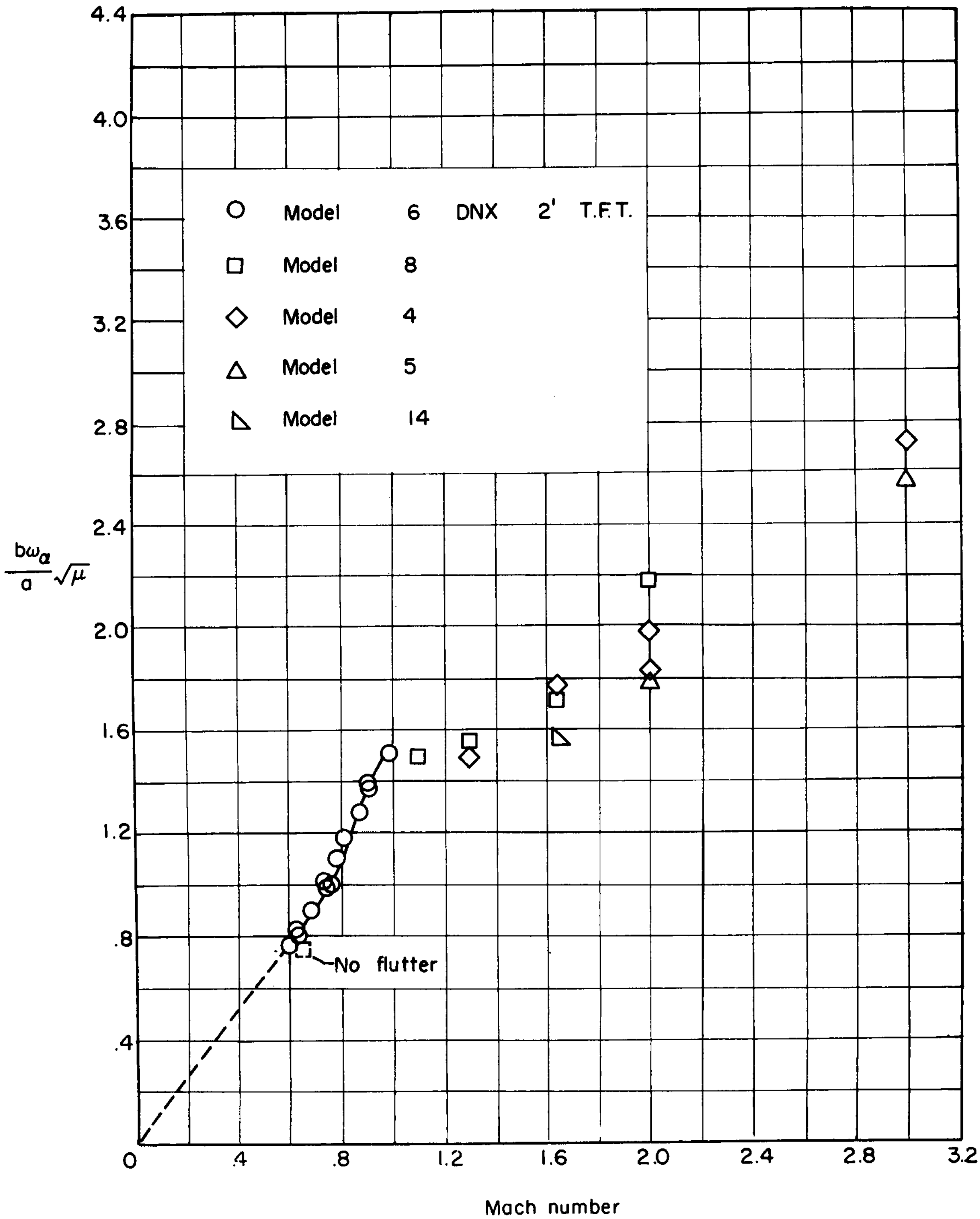


Figure 11.- Flutter curves for extended-plan-form models with nacelles.

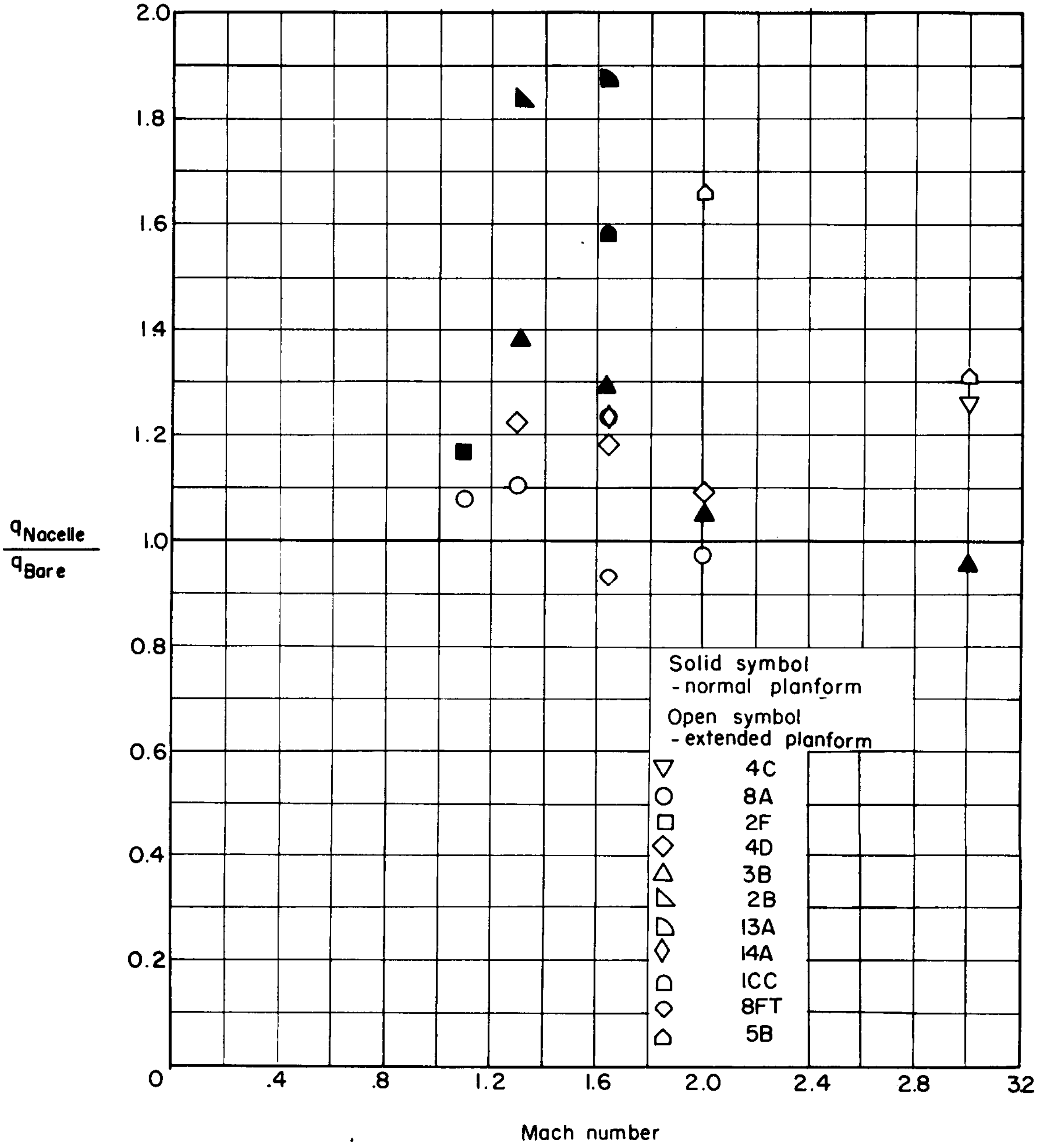


Figure 12.- Effect of nacelles on flutter.

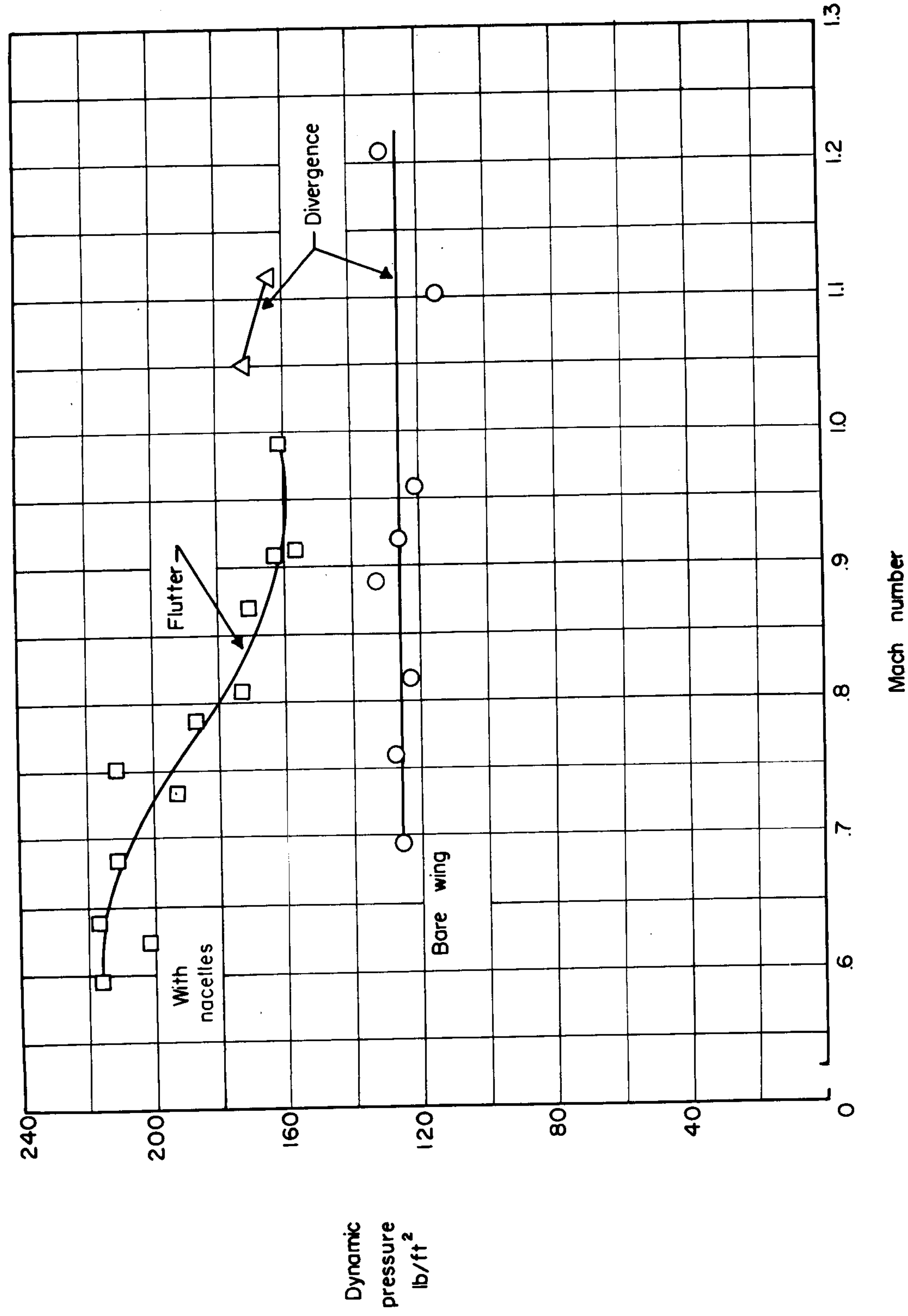


Figure 13.- Flutter and divergence curves for extended model with and without nacelles.

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WIND-TUNNEL FLUTTER TESTS AT MACH NUMBERS UP TO 3.0 OF

BOEING WING MODELS FOR WEAPONS SYSTEM 110A

COORD. NO. AF-AM-108

By G. M. Levey, W. J. Tuovila, and A. G. Rainey

ABSTRACT

Flutter tests have been conducted on two low-aspect-ratio wing plan forms under consideration by the Boeing Airplane Company for the 110A weapons system. These configurations had three heavy nacelles near the trailing edge, and flutter tests were made both with and without nacelles. Up to a Mach number of 3.0, the tests indicate that the addition of the nacelles was, in general, beneficial.

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